Global temperature change: where do we start?

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More information:
Hawkins et al., 2017, BAMS
Schurer et al., 2017, Nature Climate Change

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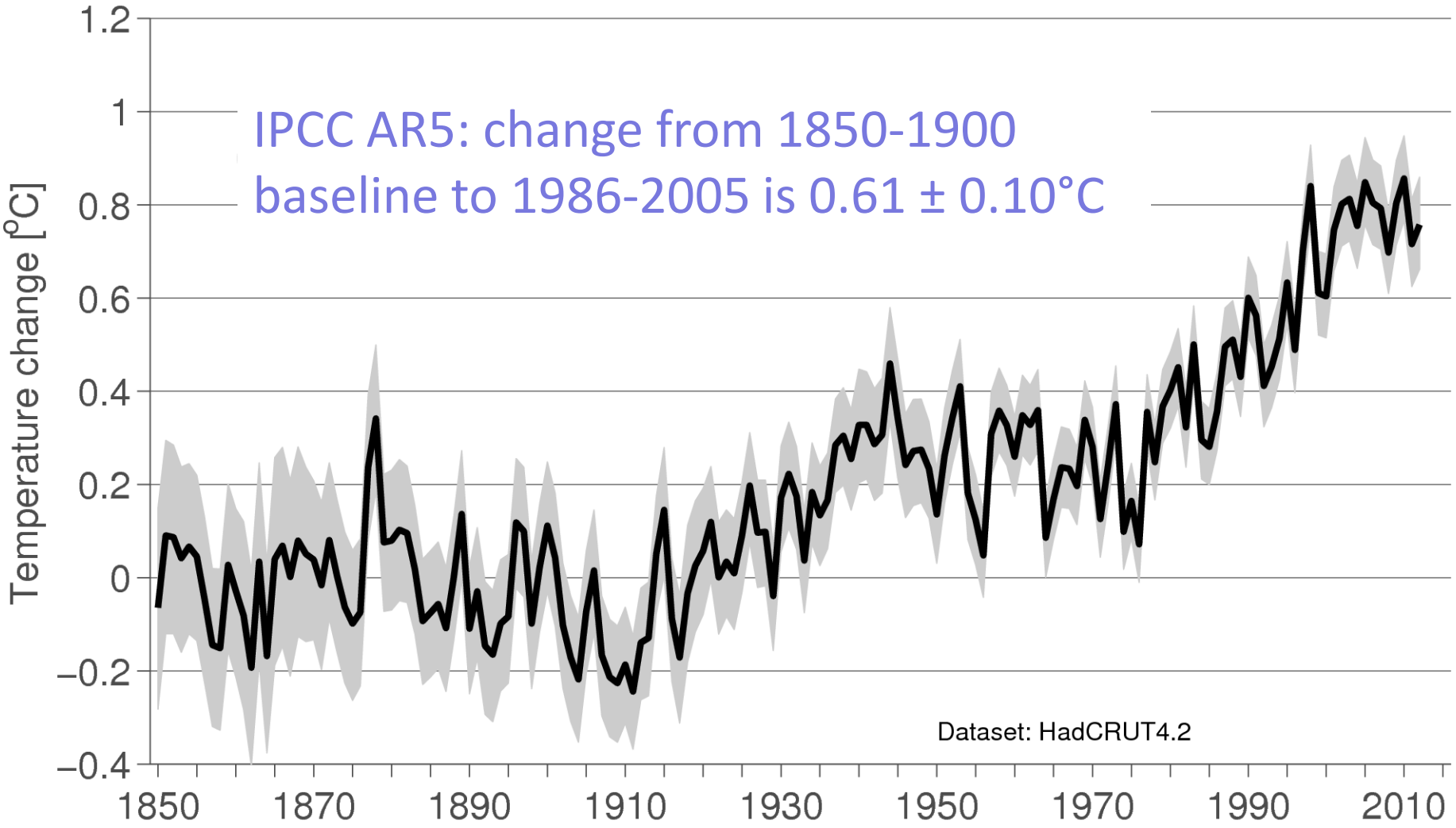
Paris Agreement aim:
"… hold the increase in global average temperature to well below 2°C above pre-industrial levels …"

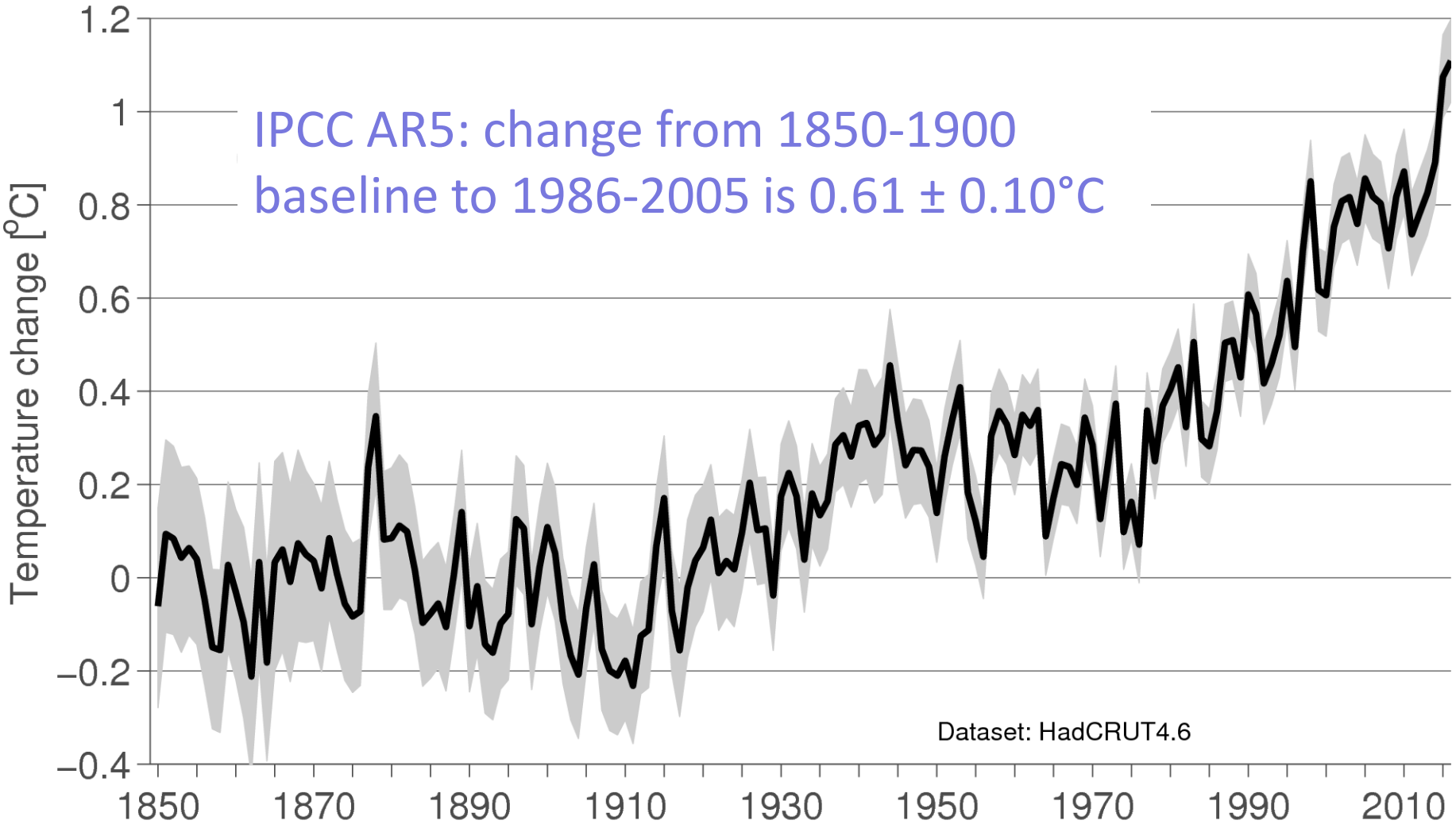
Scientific interpretation issues:

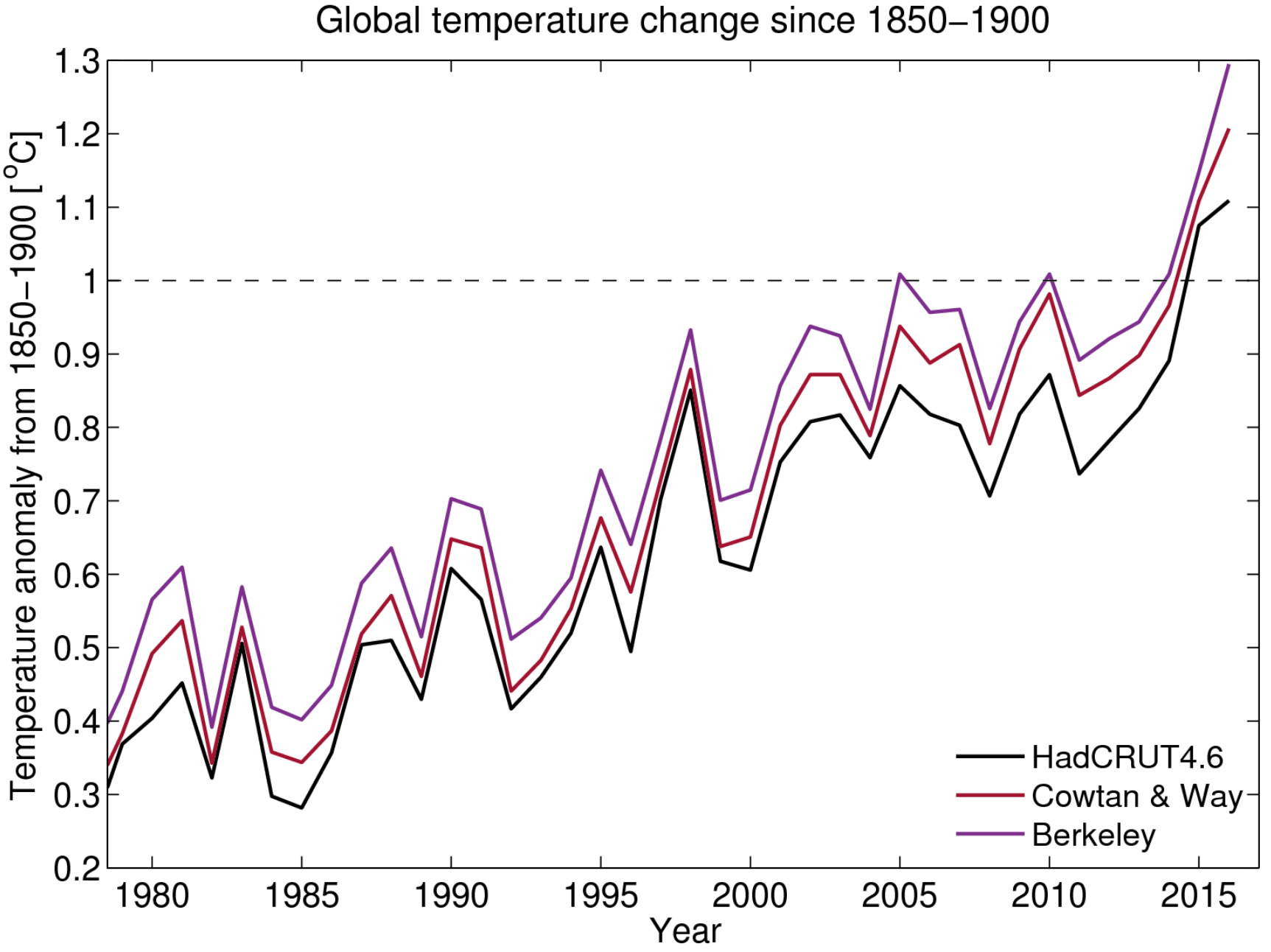
1) Is increase for anthropogenic factors only?
2) What is 'pre-industrial'?
3) What is 'global average temperature'?

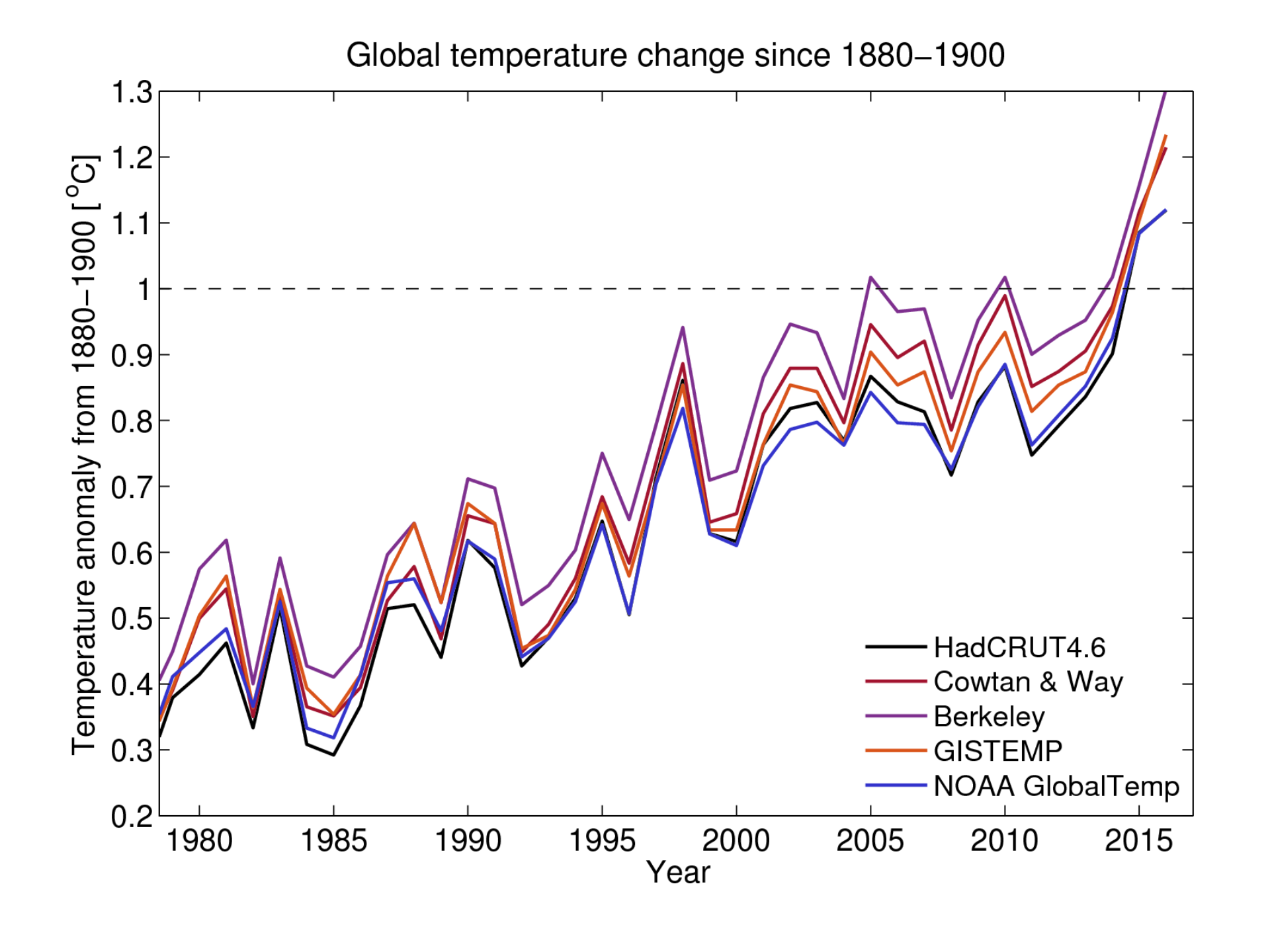
Global temperature change (1850-2012)



Global temperature change (1850-2016)




Global temperature change since 1850–1900
Temperature anomaly from 1850–1900 [°C]
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
1980
1985
1990
1995
2000
2005
2010
2015
Year
HadCRUT4.6
Cowtan & Way
Berkeley


Global temperature change since 1880–1900
Temperature anomaly from 1880–1900 [°C]
1.3
1.2
1.1
1
0.9
0.8
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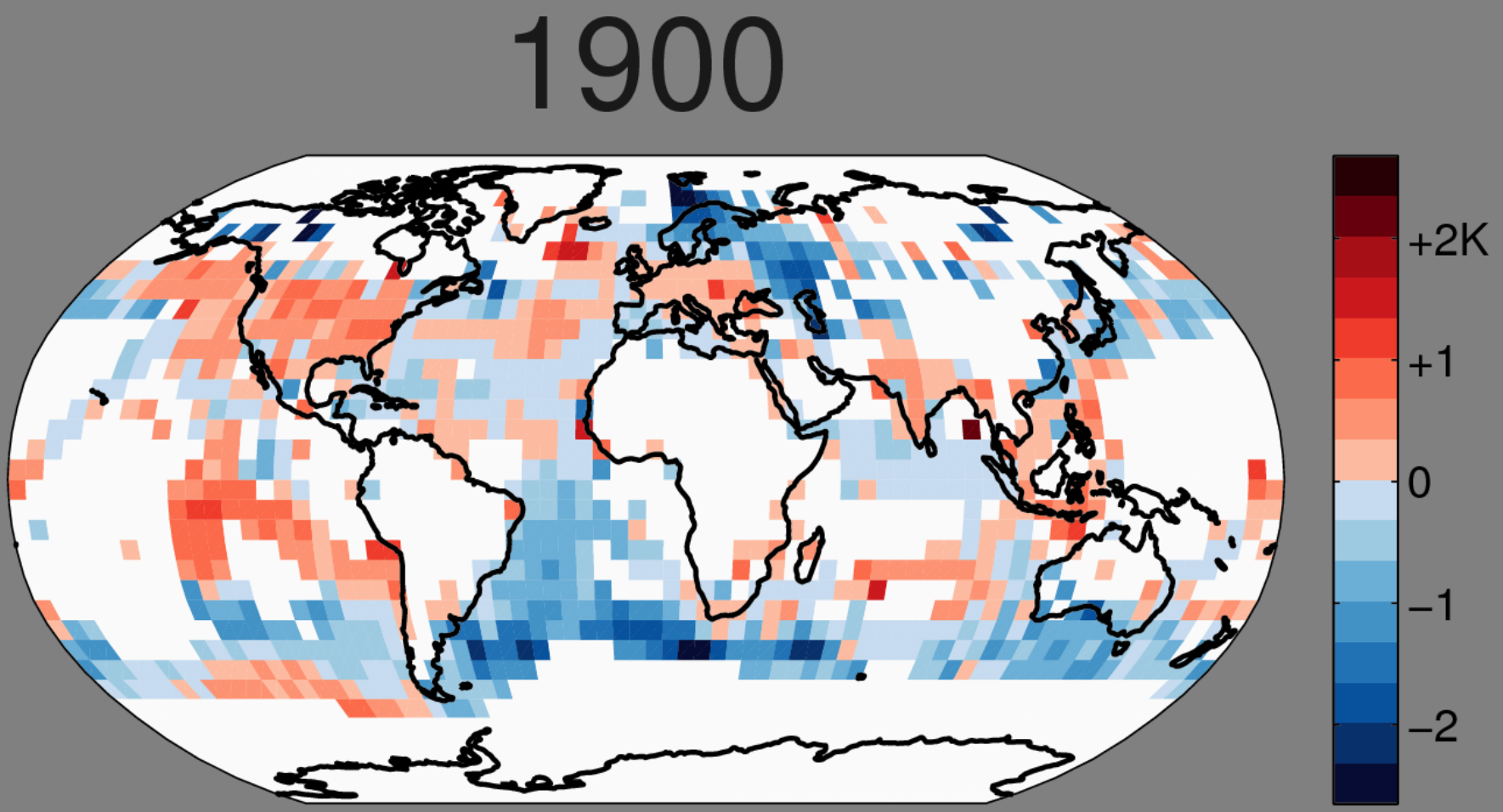
Berkeley
GISTEMP
NOAA GlobalTemp

Why the differences between data sets?



HadCRUT4.6, relative to 1961-1990

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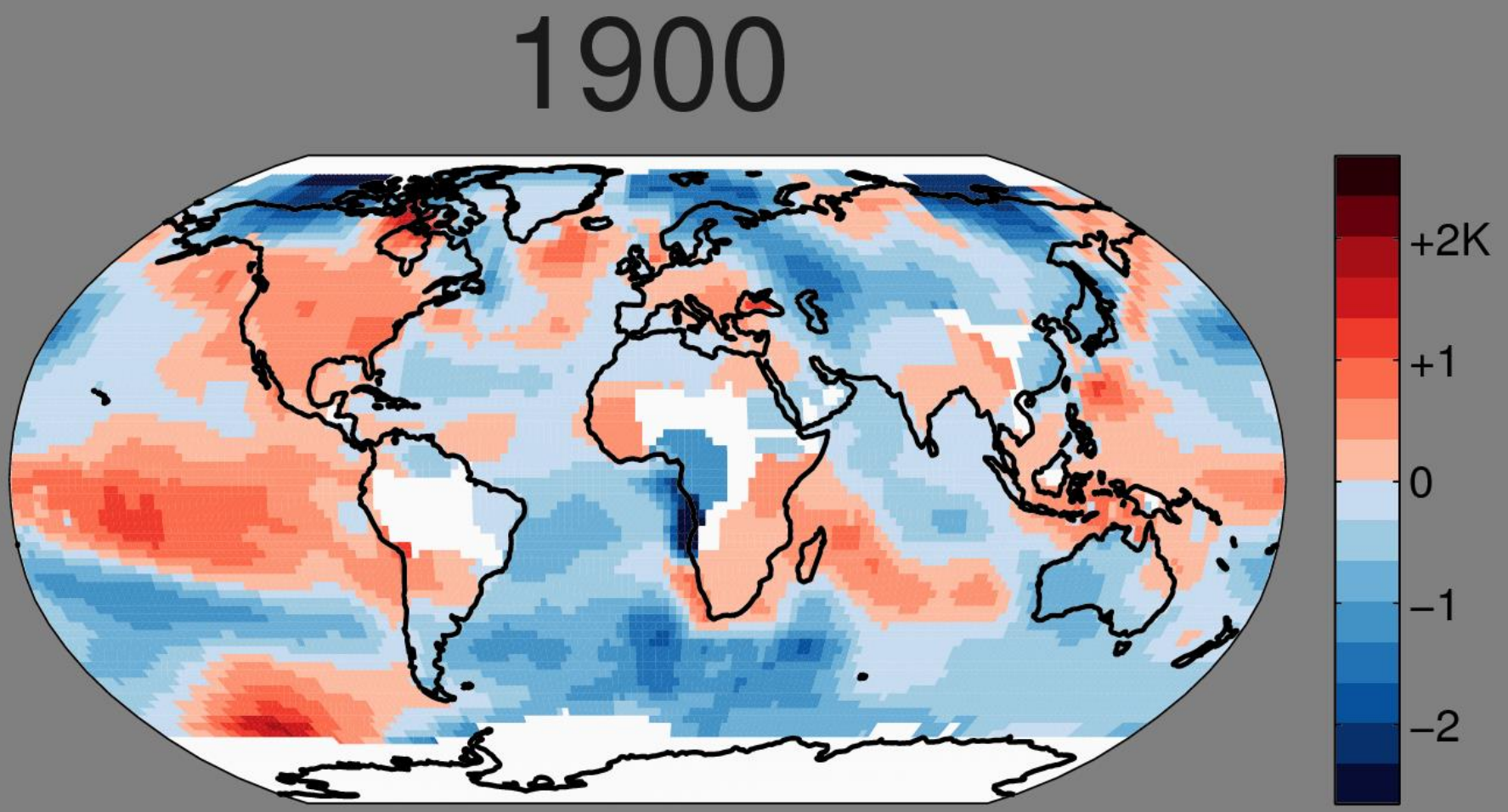

GISTEMP, relative to 1961-1990

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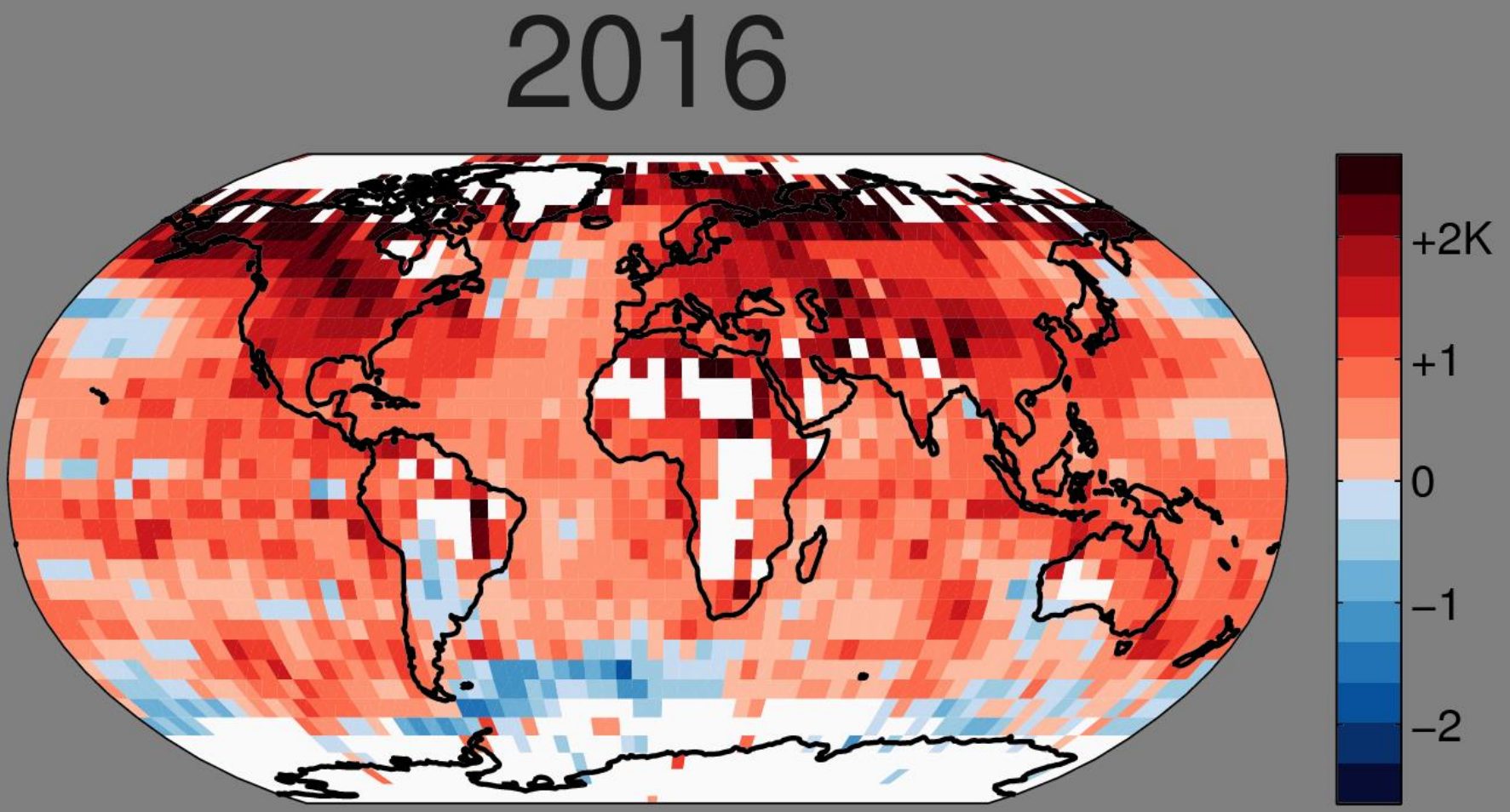

HadCRUT4.6, relative to 1961-1990

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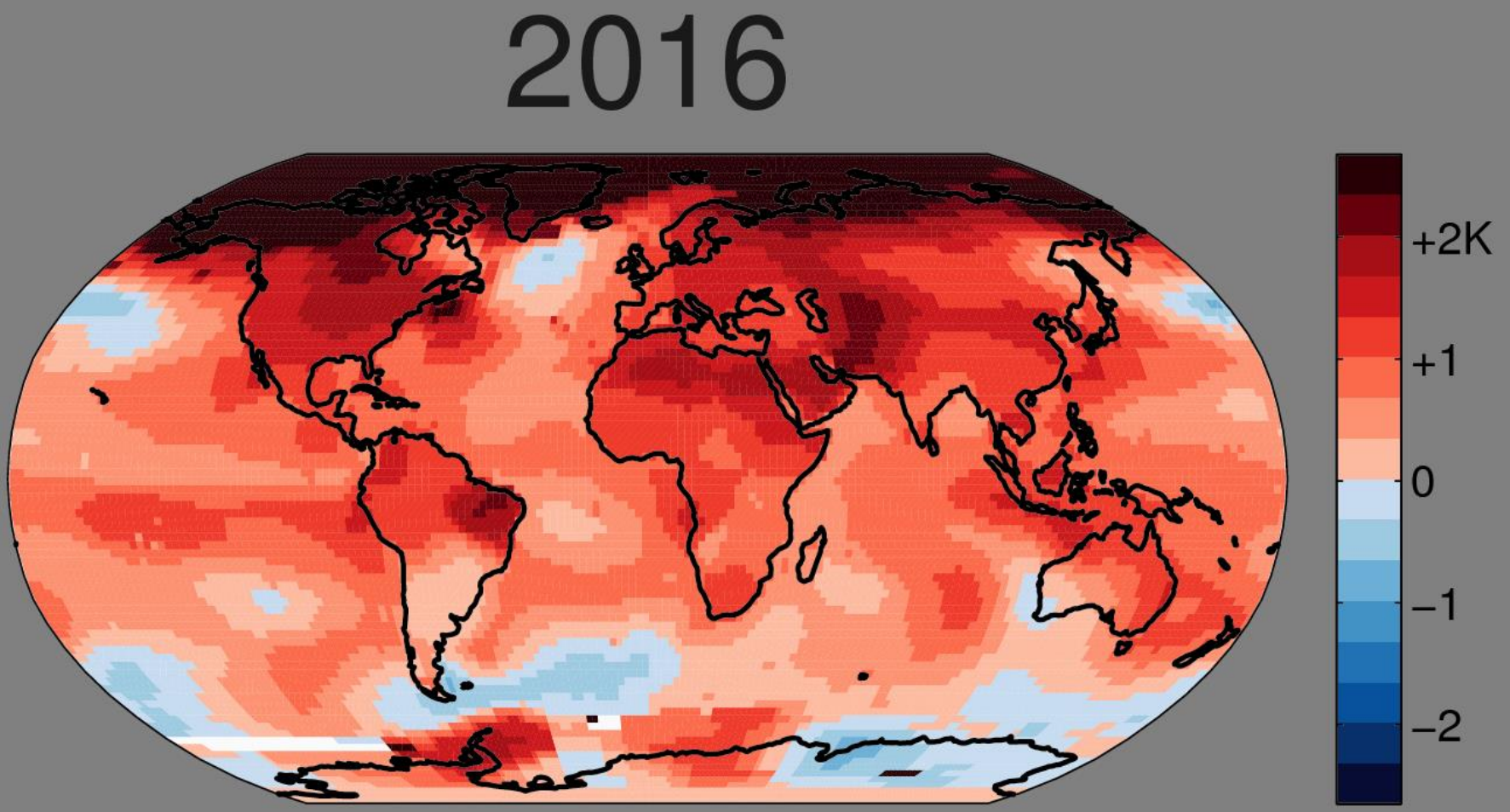
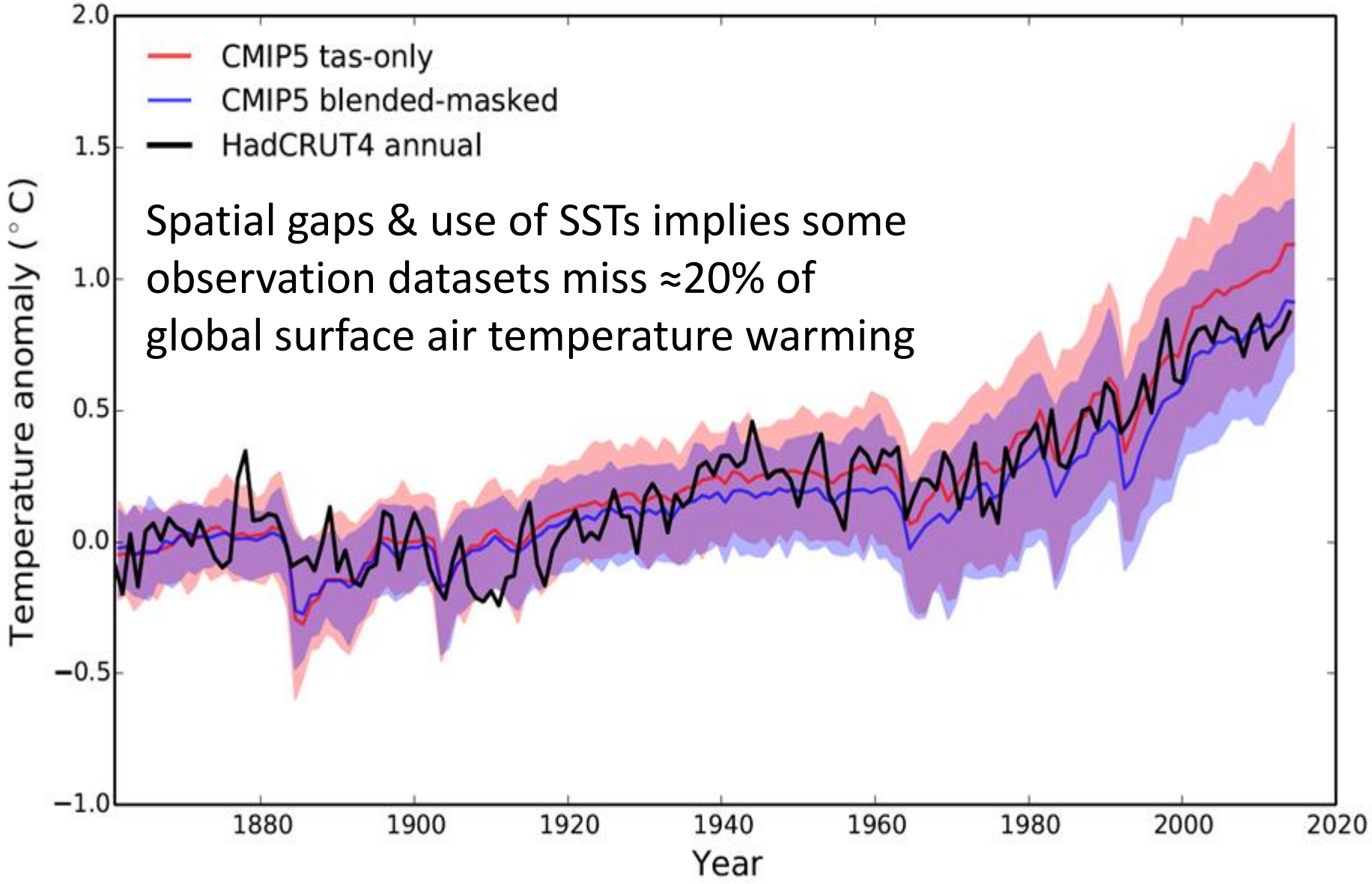


GISTEMP, relative to 1961-1990

Ensuring comparisons are like-with-like

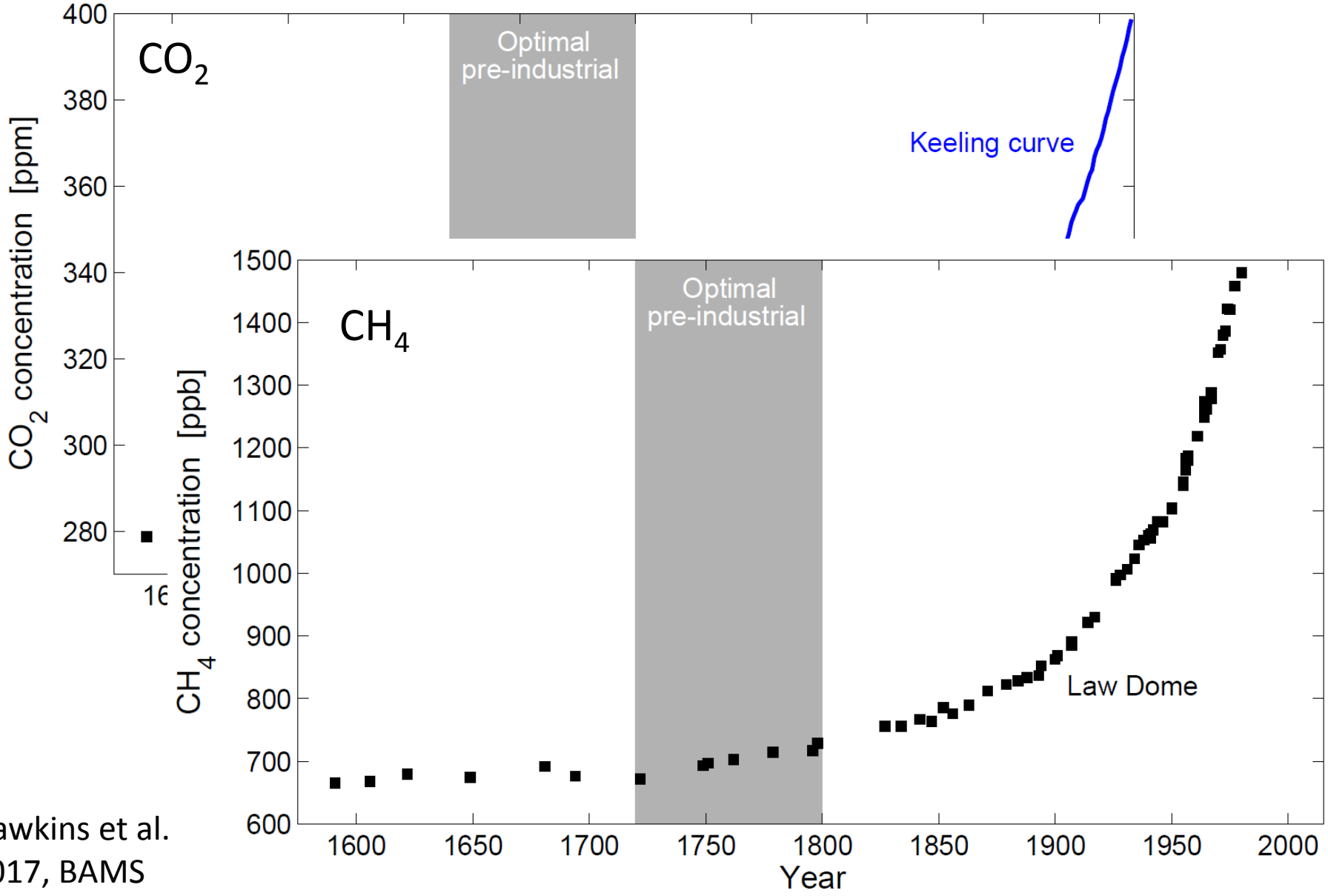


Cowtan et al 2015; Richardson et al. 2016

What period is ‘pre-industrial’?

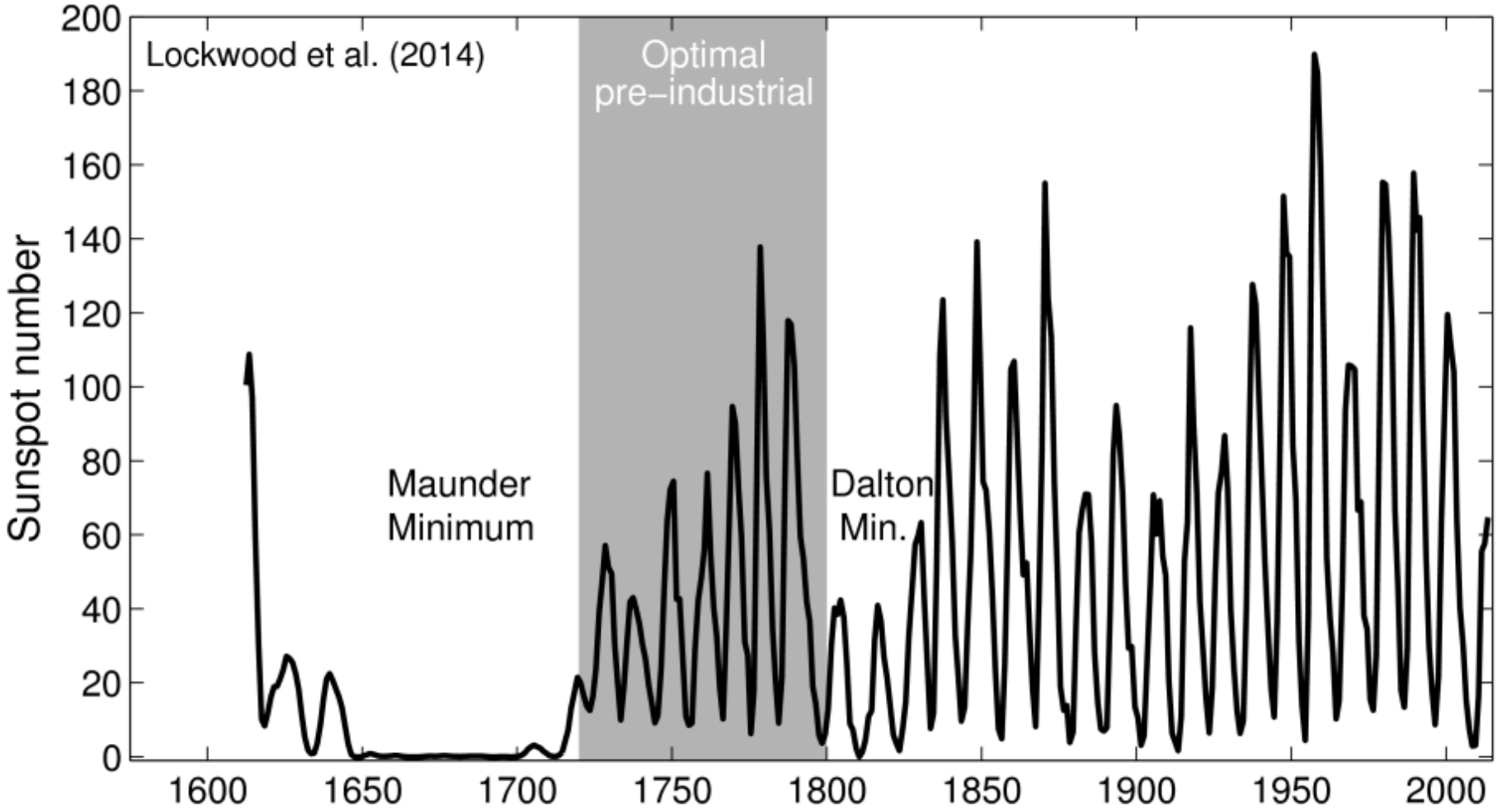
- IPCC AR5 used several different historical baselines (e.g. 1750, 1850-1900, 1861-1880, …)
- Ideal factors:
  - Low levels of anthropogenic forcings
  - ‘Normal’ levels of natural forcings
  - Long enough to average over internal variability, e.g. ENSO or Pacific/Atlantic decadal variations
  - Widespread reliable temperature observations
- Possible choice: 1720-1800

Carbon dioxide and methane



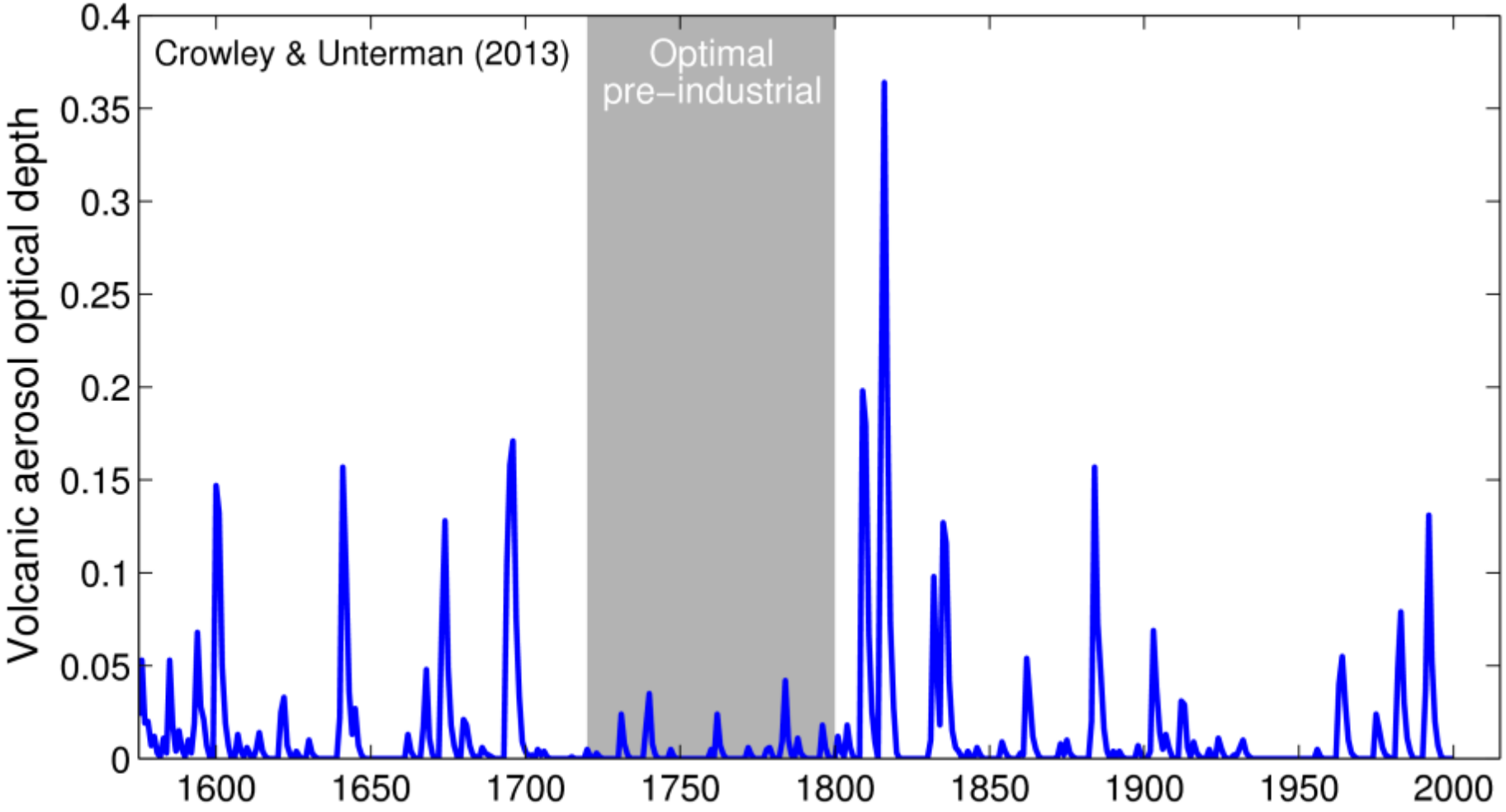
Hawkins et al. 2017, BAMS

Solar variations



Hawkins et al.
2017, BAMS

Large volcanic eruptions



Hawkins et al.
2017, BAMS

Pre-industrial assessment

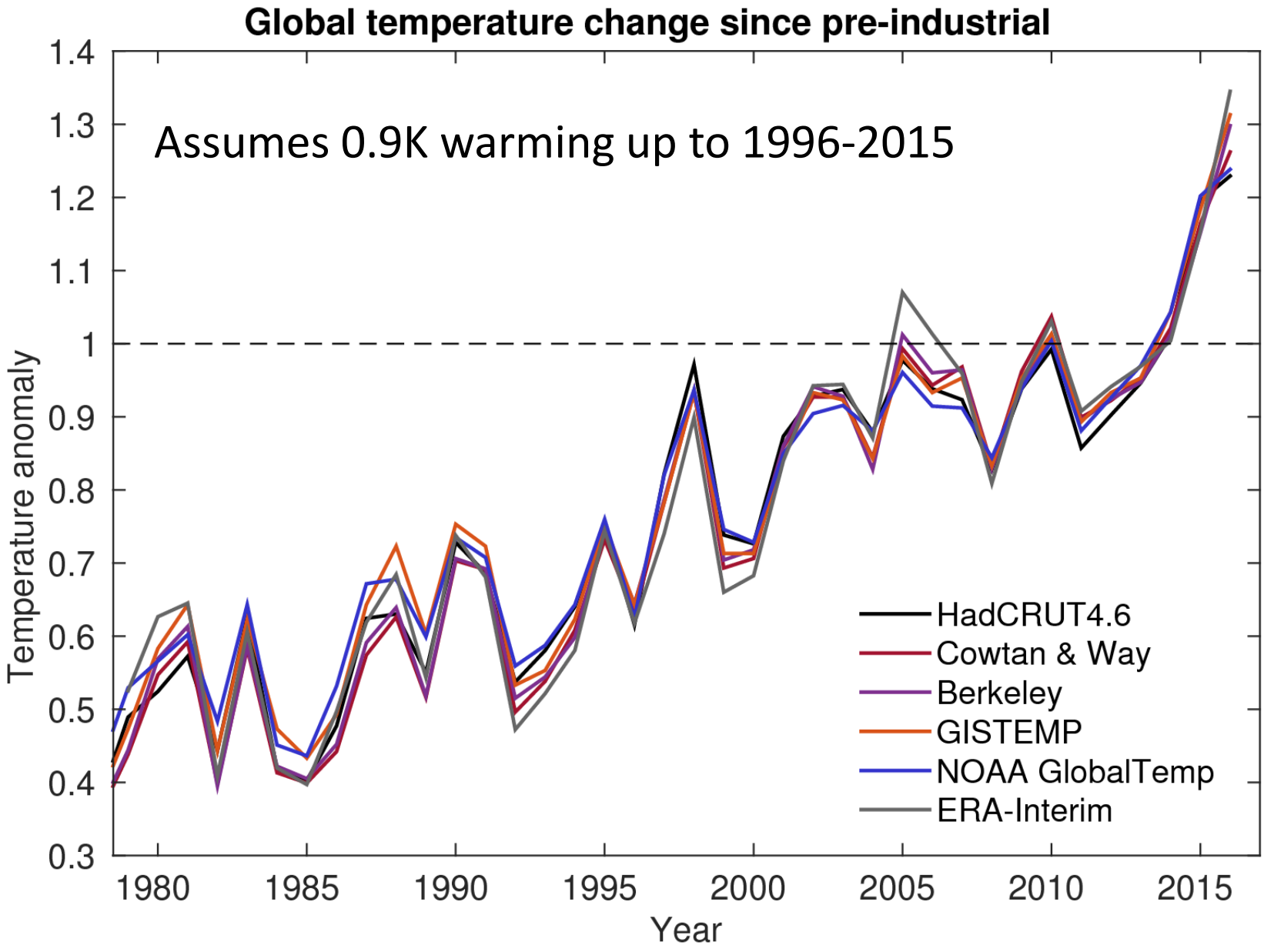
- Multiple lines of evidence suggest ‘pre-industrial’ period was globally slightly cooler than 1850-1900
  - Available long instrumental observations
  - Climate model simulations
  - Knowledge of radiative forcings
- Hawkins et al. 2017, BAMS
  Change from ‘pre-industrial’ to 1986-2005 was likely 0.55-0.75°C, or likely larger than 0.60°C
- Schurer et al. 2017, Nature Climate Change
  Change from ‘pre-industrial’ to 1850-1900 was 0.0-0.2°C (using model simulations only)

Conclusions

- Choices about baselines matter
- The ‘pre-industrial’ period was likely cooler than the start of global temperature records
- Spatially incomplete observational datasets likely underestimate the change since 1850
- Observational datasets use SSTs over ocean, likely underestimating air temperature change
- 2016 was 1.1K above 1850-1900 (HadCRUT4)
- Depending on definitions of ‘global average temperature’ and ‘pre-industrial’, can likely add 0.1-0.3K due to three factors above

Discussion and implications

- Climate impact studies tend to assume 1.5°C or 2°C using surface air temperature everywhere
- Is any warming pre-1850 relevant for policy?
- Should UNFCCC abandon ‘pre-industrial’?
- Alternative would be to fix the temperature change up to certain recent period, e.g.
  - assume warming up to 1996-2015 was 0.9°C
  - or set new target based on warming from now
- Need to ensure all historical meteorological observations are openly available and enhance weather ‘data rescue’ activities to fill gaps


Global temperature change since pre-industrial
Assumes 0.9K warming up to 1996-2015
Temperature anomaly
Year
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1980
1985
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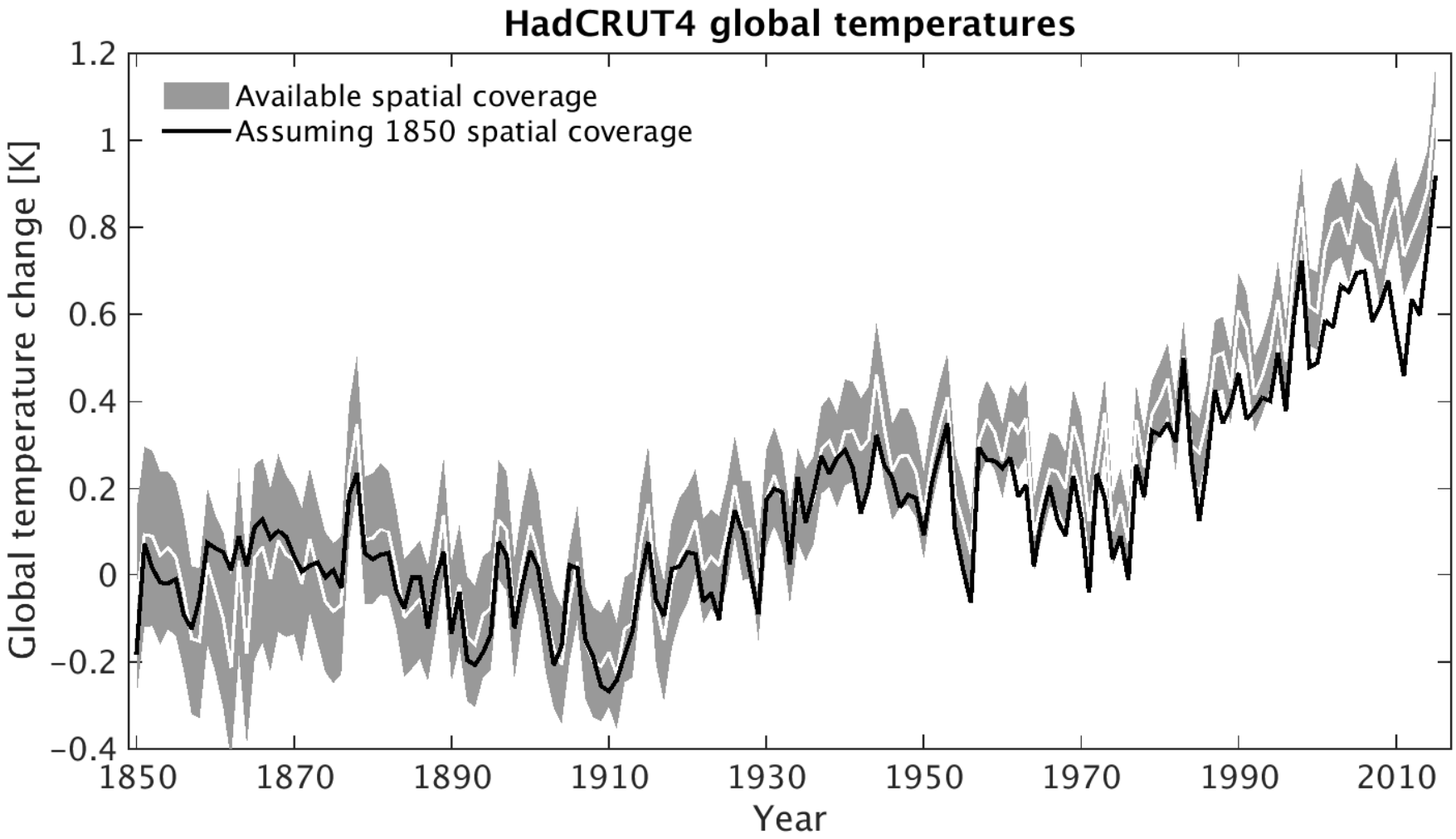
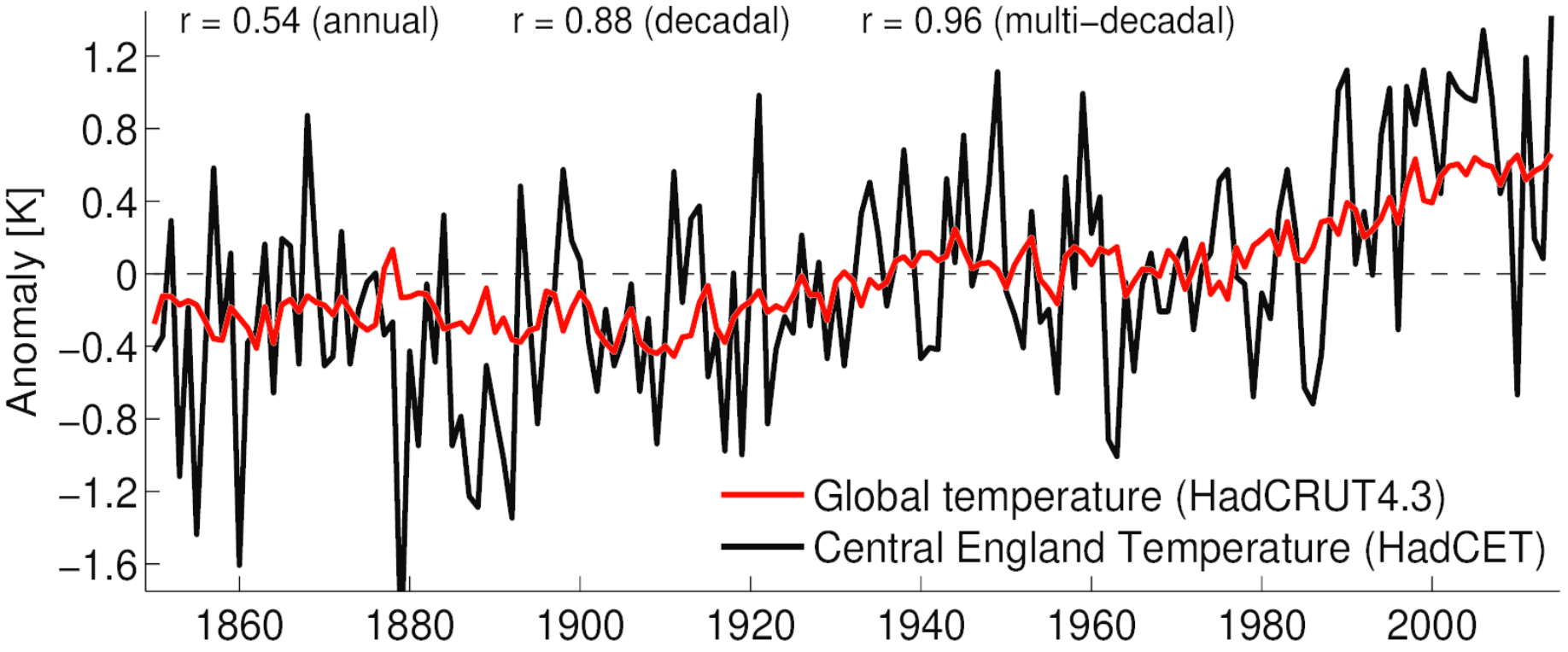
ERA-Interim


HadCRUT4 global temperatures
Available spatial coverage
Assuming 1850 spatial coverage
Global temperature change [K]
1.2
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
1850
1870
1890
1910
1930
1950
1970
1990
2010
Year

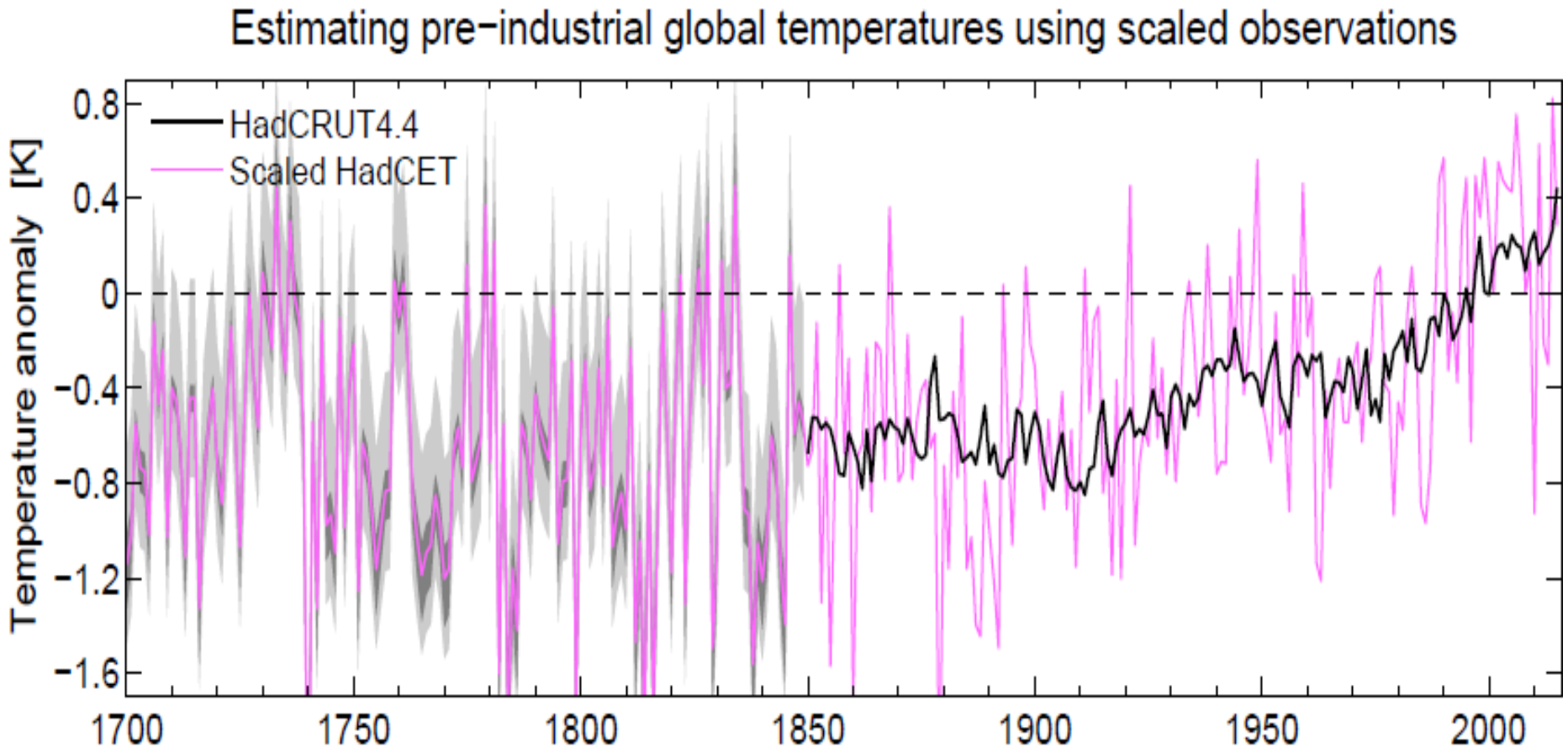
Using long instrumental records

How well does a single location represent global mean?



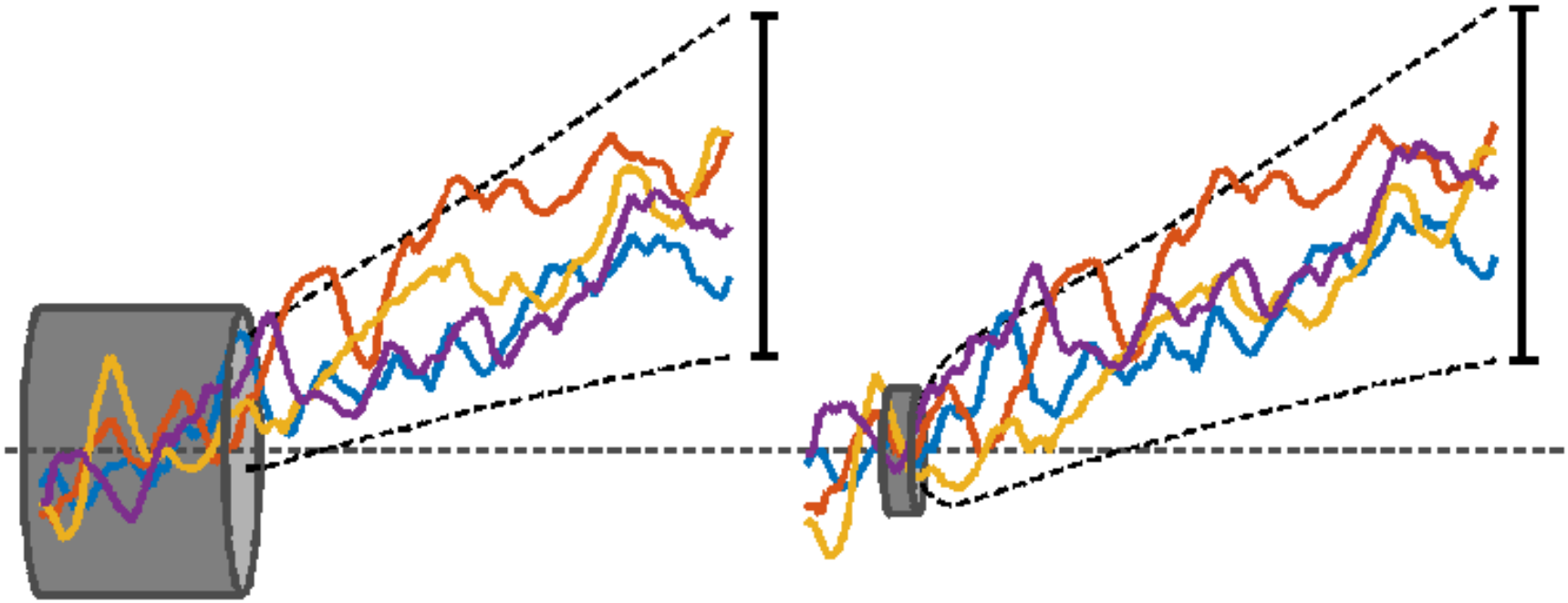
Sutton, Suckling & Hawkins, 2015, Phil Trans A

Using long instrumental records



Hawkins et al.
2017, BAMS

Varying time & length of baseline



Hawkins & Sutton, BAMS, 2016

Last millennium GCM simulations

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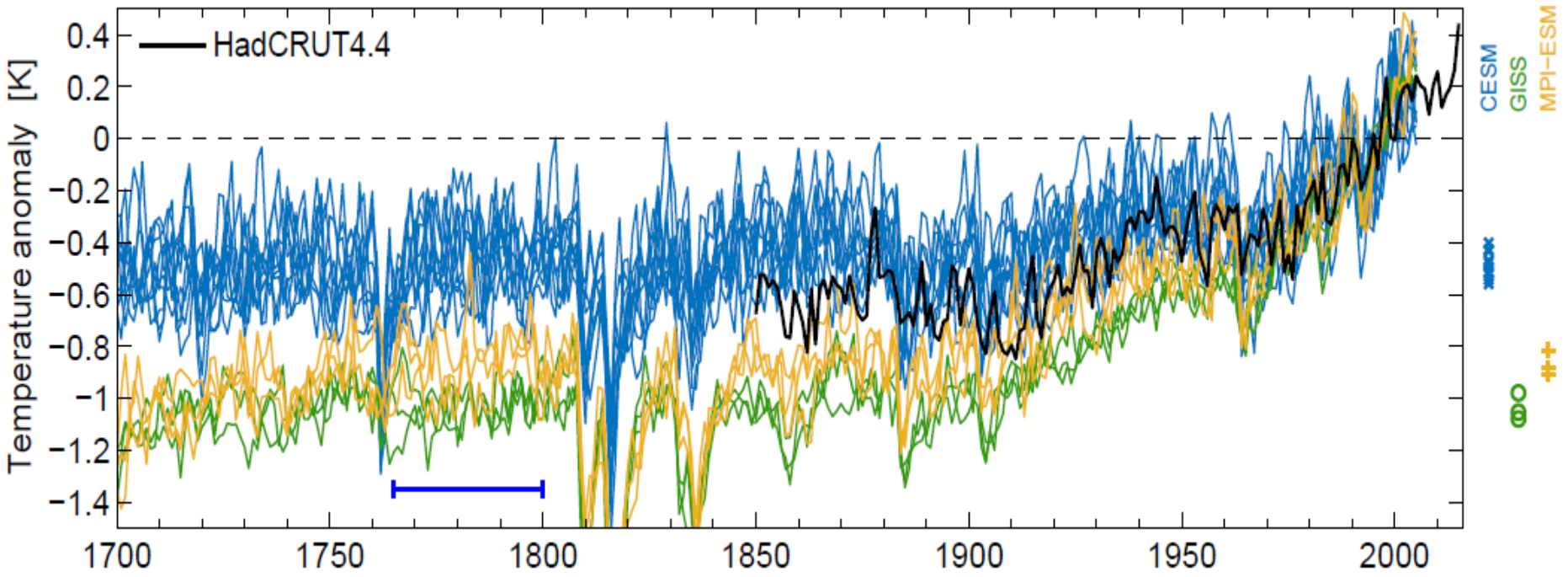

- Simulations inconsistent for change since pre-industrial to present
- But, agree that 1720-1800 cooler than 1850-1900 by 0.0-0.1°C
- Variations between ensemble members about ±0.1°C

Using radiative forcings

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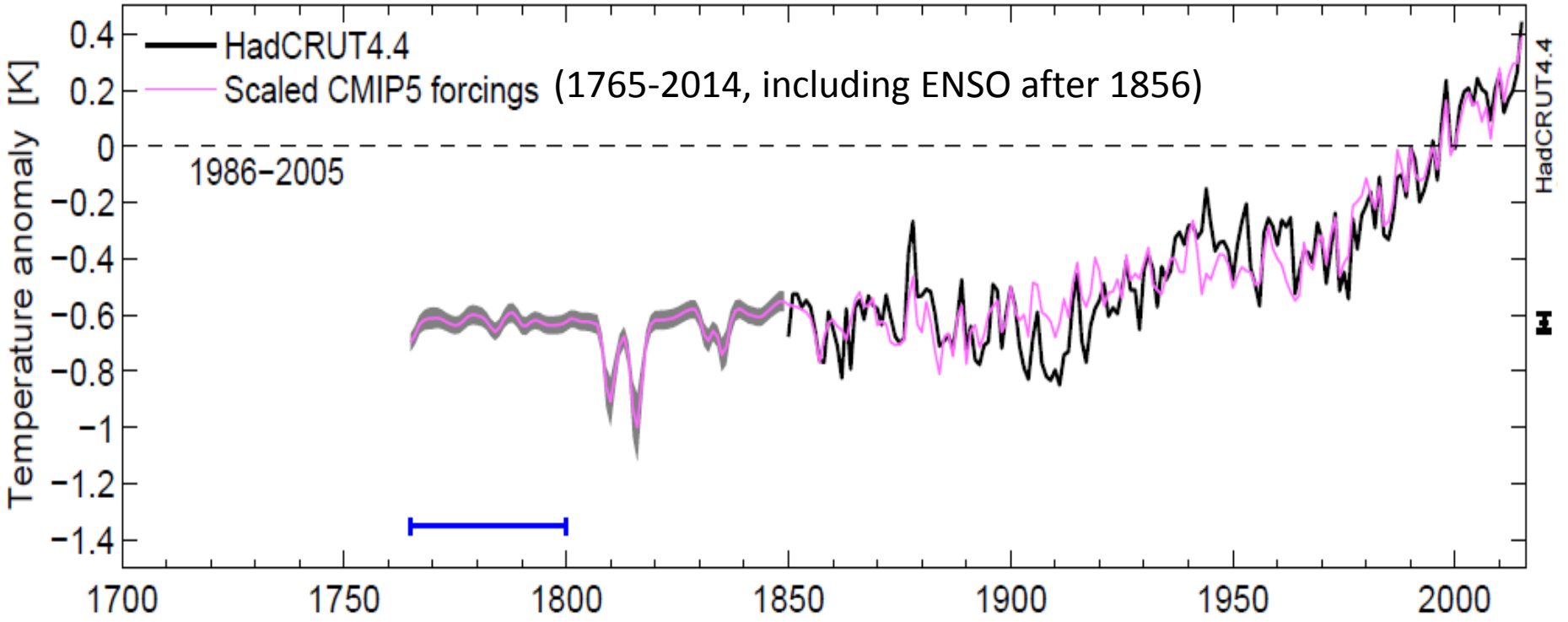

- Scaled radiative forcings suggest 1765-1800 was cooler than 1850-1900 by 0.00-0.02°C
- CMIP5 does not provide radiative forcings before 1765